Attorney Docket: TIW-37

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, Britt O. Braddick, have invented new and useful improvements in a

DOWNHOLE TUBULAR PATCH, TUBULAR EXPANDER AND METHOD

of which the following is a specification:

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By: Jim Webster

DOWNHOLE TUBULAR PATCH, TUBULAR EXPANDER AND METHOD

Field of the Invention

The present invention relates to downhole tools and techniques used to radially expand a downhole tubular into sealing engagement with a surrounding tubular. More particularly, this invention relates to a technique for forming a downhole tubular patch inside a perforated or separated tubular utilizing a conventional interior tubular and a tool which forms an upper seal and a lower seal above and below the region of the perforation or separation. The invention also involves a tubular expander for expanding a downhole tubular, and a patch installation and tubular expander method.

Background of the Invention

Oil well operators have long sought improved techniques for forming a downhole patch across a tubular which has lost sealing integrity, whether that be due to a previous perforation of the tubular, high wear of the tubular at a specific downhole location, or a complete separation of the tubular. Also, there are times when a screened section of a tubular needs to be sealed off. A tubular patch with a reduced throughbore may then be positioned above and below the zone of the larger diameter tubular which lost its sealing integrity, and the reduced diameter tubular then hung off from and sealed at the top and bottom to the outer tubular. In some applications, the patch may be exposed to high thermal temperatures

which conventionally reduce the effectiveness of the seal between the tubular patch and the outside tubular. In heavy oil recovery operations, for instance, steam may be injected for several weeks or months through the tubular, downward past the patch, and then into a formation.

U.S. Patent No. 5,348,095 to Shell Oil Company discloses a method of expanding a casing diameter downhole utilizing a hydraulic expansion tool. U.S. Patent No. 6,021,850 discloses a downhole tool for expanding one tubular against a larger tubular or the borehole. Publication U.S. 2001/0020532 A1 discloses a tool for hanging a liner by pipe expansion. U.S. Patent No. 6,050,341 discloses a running tool which creates a flow restriction and a retaining member moveable to a retracted position to release by the application of fluid pressure.

Due to problems with the procedure and tools used to expand a smaller diameter tubular into reliable sealing engagement with a larger diameter tubular, many tools have avoided expansion of the tubular and used radially expandable seals to seal the annulus between the small diameter and the large diameter tubular, as disclosed U.S. Patent No. 5,333,692. Other patents have suggested using irregularly shaped tubular members for the expansion, as disclosed in U.S. Patent Nos. 3,179,168, 3,245,471, 3,358,760, 5,366,012, 5,494,106, and 5,667,011. U.S. Patent No. 5,785,120 discloses a tubular patch system with a body and selectively expandable members for use with a corrugated liner patch. U.S. Patent No. 6,250,385 discloses an overlapping expandable liner. A sealable

perforating nipple is disclosed in U.S. Patent No. 5,390,742, and a high expansion diameter packer is disclosed in U.S. Patent No. 6,041,858.

Various tools and methods have been proposed for expanding an outer tubular while downhole, utilizing the hydraulic expansion tool. While some of these tools have met with limited success, a significant disadvantage to these tools is that, if a tool is unable to continue its expansion operation (whether due to the characteristics of a hard formation about the tubular, failure of one or more tool components, or otherwise) it is difficult and expensive to retrieve the tool to the surface to either correct the tool or to utilize a more powerful tool to continue the downhole tubular expansion operation. Accordingly, various techniques have been developed to expand a downhole tubular from the top down, rather than from the bottom up, so that the tool can be easily retrieved from the expanded diameter bore, and the repaired or revised tool then inserted into the lower end of the expanded tubular.

The disadvantages of the prior art are overcome by the present invention, and an improved system for forming a patch in a well and a location along the downhole tubular string which has lost sealing integrity is hereafter disclosed. The system includes a tubular patch with a central patch body, an upper expander body, and a lower expander body, and a running tool with a top expander and a bottom expander to move the tubular patch into sealing engagement with the downhole tubular string. The present invention also discloses a tubular expansion running tool

and method which may be reliably used to expand a downhole tubular while facilitating retrieval of the tool and subsequently reinsertion of the tool through the restricted diameter downhole tubular.

Summary of the Invention

A system for forming a patch in a well includes a tubular patch for positioning within the downhole tubular string at a location that has lost sealing integrity. The tubular patch is supported on a running tool suspended in the well from a work string. The tubular patch includes a central patch body having a generally cylindrical central interior surface, an upper expander body having a generally cylindrical upper interior surface and an upper exterior seal, and a lower expander body having a generally cylindrical lower interior surface and a lower exterior seal. The tubular patch may also include an expansion joint positioned between the upper expander body and the lower expander body to compensate for expansion and contraction of the tubular patch caused by thermal variations between the tubular patch and the tubular string exterior of the patch. The running tool includes an inner mandrel that is axially movable relative to the central patch body, and one or more pistons each axially movable relative to the inner mandrel in response to fluid pressure within the running tool. A top expander is axially moveable downward relative to the upper expander body in response to axial movement of or one or more pistons, and a bottom expander axially moves upward relative to the lower expander body in response to axial movement of the one or more pistons. The one

or more pistons preferably includes a first plurality of pistons for moving the top expander relative to the upper expander body, and a second plurality of pistons for moving the bottom expander relative to the lower expander body. Each of the upper expander body and lower expander body may include a set of slips for gripping engagement with the inner surface of the tubular string.

It a feature of the present invention that the lower expander includes a first plurality of axially-spaced expander segments and a second plurality of axially-spaced expander segments. Each of the second plurality of expander segments is spaced between adjacent first expander segments and is axially movable relative to the first expander segments. When the first and second plurality of expander segments are vertically aligned, the expander segments together expand the lower expander body as they are moved upward through the lower expander body. When the first expander segments are axially spaced from the second expander segments, the expander segments of the running tool may be passed through the central patch body for purposes of installing the running tool on the tubular patch and for retrieving the running tool to the surface after setting of the tubular patch.

It is a feature of the present invention that an outer sleeve interconnects a first plurality of cylinders to the top expander, and that a shear member may be provided for interconnecting the outer sleeve and the running string.

A related feature of the invention is that another shear member may be provided for disconnecting the first plurality of pistons and the top expander after a selected axial movement of the top expander relative to the upper expander body.

It is a feature of the invention that exterior seals may each be formed from a variety of materials, including a graphite material.

It is another feature of the invention that an expansion joint may be provided between the upper expander body and the lower expander body for thermal expansion and/or contraction of the central patch body.

Still another feature of the invention is that the running tool may be provided with a plug seat, so that a plug landed on the seat achieves an increase in fluid pressure within the running tool and to the actuating pistons.

Another significant feature of the present invention is that a running tool and method are provided for expanding a downhole tubular while within the well. Hydraulic pressure may be applied to the tool to act on the lower expander to either expand an outer tubular, or to expand the lower expander body of the thermal patch. The expander members may be positioned between axially aligned positions for expanding the downhole tubular and axially separated positions for allowing the expander members to collapse allows the running tool to be easily retrieved to the surface.

Yet another feature of the invention is that a plurality of dogs or stops may be provided on the running tool for preventing axial movement of the upper

expander body in response to downward movement of the upper expander, and axial movement of the lower expander body in response to upward movement of the lower expander. The dogs may move radially inward to a disengaged position for purposes of installing the running tool on the tubular patch and for retrieving the running tool after installation of the tubular patch. Each of a plurality of dogs may be biased radially outward to an engaged position within the controlled gap of the expansion joint.

It is a significant advantage that the system for forming a patch in a well according to the present invention utilizes conventional components with a high reliability. Also, existing personnel with a minimum of training may reliably use the system according to the present invention, since the invention relies upon utilizing well-known surface operations to form the downhole patch.

These and further objects, features and advantages of the present invention will become apparent from the following detailed description, wherein reference is made to the figures in the accompanying drawings.

Brief Description of the Drawings

Figures 1A through 1J illustrate sequentially (lower) components of the patch system according to the present invention. Those skilled in the art will appreciate that line breaks along the vertical length of the tool may eliminate well known structural components for inter connecting members, and accordingly the actual length of structural components is not represented. The system as shown in Figure 1 positions show the running tool on a work string, with the running tool supporting a tubular patch in its run-in configuration.

Figures 2A-2D illustrates components of the running tool partially within the central patch body during its installation on the tubular patch at the surface.

Figure 3A illustrates components of the running tool with the ball landed to increase fluid pressure to expand the upper expansion body and to shear the upper shear collar.

Figure 4A shows the lower end of the running tool configured for withdrawing the running tool from the tubular patch to the surface.

Detailed Description of Preferred Embodiments

Figures 1A -1J disclose a preferred system for forming a patch in a well at a location along a downhole tubular string that has lost sealing integrity. The running tool is thus suspended in a well from the work string WS, and positioned within the casing C. The system of the present invention positions a tubular patch within the downhole casing C at a location that has lost sealing integrity, with the tubular patch being supported on the running tool 10 and thus suspended in the well from the work string WS.

Figures 1D - 1H depict the tubular patch of the present invention along with various components of the running tool. When installing the patch within a well, the patch is assembled from its lowermost component, the lower expander body 98, to its uppermost component, the upper expander body 52, and lowered into the well and suspended at the surface. The lower expander body 98 is attached by thread connection 96 at its upper end to the expansion joint mandrel 86, as shown in Figures 1G and 1H. The expansion joint mandrel extends into a honed seal bore of the expansion joint body 70 and maintains sealing engagement therewith by a dynamic metal-to-metal ball seal 81 on expansion joint mandrel 86. A sealed expansion joint thus allows thermal expansion and contraction of the thermal patch secured at the upper and lower ends to the casing. A controlled gap 71 of a selected axial length, located between the shoulder 61 and the top end 83 of the expansion joint mandrel 86, is maintained by shear pins 94 (Figure 1B) extending

from the retainer 92, which is threadedly attached to the bottom 84 of the of the expansion joint body 70. Figures 1E and 1F depict a portion of the central patch body 60 of the tubular patch. The central patch body 60 extends upward from the expansion joint body 70 to the upper expander body 52, as shown in Figure 1D. The central patch body 60, in many applications, may have a length of from several hundred feet to a thousand feet or more. Both the lower expander body 98 and the upper expander body 52 preferably have a generally cylindrical interior surface and support one or more vertically spaced respective external seals 102,104 and 54, 56 formed from a suitable seal material, including graphite. Graphite base packing forms a reliable seal with the casing C when the expander bodies are subsequently expanded into sealing engagement with the casing. Both the lower expander body 98 and upper expander body 52 also preferably include a plurality of respectively circumferential-spaced slips 106, 58. The foregoing assembled tubular patch is thus suspended at the surface of the well, prepared for installation of the running tool.

The running tool 10 is assembled in two halves to facilitate installation and support of the tubular patch thereon. The lower half of the running tool is illustrated in Figures 2B -2E and Figures 1C -1J, while the upper half of the running tool is illustrated in Figures 1A - 1C and Figure 2A. In Figures 2C and 2D, the I.D. of the central patch body 60 is shown by line 61.

Referring to Figures 1G and 1H, the lower body 108 of the running tool 10 is attached to the lower end of the running tool mandrel 14. An inner collet ring 112 is slidably supported about the lower body 108. A plurality of collet fingers 116 extends downward from the collet ring 112. An outer collet ring 114 is slidably supported about the inner collet ring 112, and a plurality of collet fingers 118 extend downward from collet ring 112. The outer collet ring is connected to the inner collet ring by limit screw 115 that is slidable within slot 113 in the outer collet ring. When in the position shown in Figure 1H, the expanded position, each of the collet fingers includes a lower end 120 with a radially expanding outer curved surface 121. Shear collar 124 is threaded at 122 to body 108 and engages the lower collar support surface 111 to fix the downward position of the lower ends 120 when expanding the lower expander body 98. The inner surface 110 on each of the lower ends 120 thus engages the upper surface of shear collar 124 to prevent the collet fingers 116 and 118 from flexing inward radially during the expanding operations. The expanders are circumferentially interlaced, as shown in Figure 1J, during the expansion of the lower expansion body. The outer collet ring 114 has an upper extension 100 that serves to release the collets, and will be discussed in detail below.

The running tool mandrel 14 extends upward and is threadedly connected with the connector 65 having a stop surface 66 for engagement with sleeve 64. Sleeve 64 includes an upper portion having an enlarged diameter 73, and a lower

portion 88 having a reduced diameter 87, as shown in Figures 1F-1G. A collar 90 is positioned at the lower end of the sleeve 88, with both sleeve 64 and collar 90 being in sliding engagement with mandrel 14. A cage 68 is supported in sliding engagement about the sleeve 64 and contains a plurality of windows 69 (see Figure 2C) with retaining lugs 67 spaced radially about cage 68. A plurality of dogs 74 each extend through a respective window 69. The dogs 74 are furnished with upper lugs 78 and lower lugs 67 that limit radial movement of each dog within the windows. The dogs 74 prevent closing of the control gap 71 in the expansion joint 70 to prevent downward movement of the upper expander body in response to the top expander and upward movement of the lower expander body in response to the lower expander. A biasing member, such as spring 76, exerts a radially outward bias force on the dog 74. When the cage 68 and dogs 74 assembly are position about the enlarged diameter 73 of sleeve 64, the dogs are locked in an outward radial position. When the cage 68 and dogs 74 assembly are position about the reduced diameter 87 of sleeve 64, the dogs are released and can be moved radially inward within the respective window when an inward compressive force is applied to the dogs.

The lower half of the running tool, as thus assembled as discussed above, is run inside the tubular patch that is suspended within and from the surface of the well. Additional lengths of mandrel 14 and connectors 65 are threadedly made-up to the connector shown in Figure 1F to correspond with the length of central patch

body 60 of the tubular patch. As the lower half of the running tool is lowered into the tubular patch, the lower ends 120 of inner collet fingers 116 and outer collet fingers 118 are moved upward relative to the lower body 108 so as to position the lower ends 120 adjacent the reduced diameter 109 of lower body 108. Additionally, the inner collet ring 112 is moved upward relative to the outer collet ring 114, until limit pin 115 contacts the upper end of slot 113, as shown in Figure 2D. This permits the upper and lower collet fingers to flex radially inward to the reduced diameter 109 of lower body 108 and allows the lower ends 120 to pass through the reduced internal diameter of the central patch body 60. Similarly, referring to Figure 2C, the cage 68 is positioned adjacent the reduced diameter 87 of sleeve 64, allowing dogs 74 to be pressed inwardly, until the cage 68 has been lowered to a position adjacent the reduced internal diameter 49 of the upper expander body 52 (see Figures 1D-1F) by engagement of stop surface 66 on collar 65 with the top of sleeve 64. The cage 68 and dogs 74 may maintain this position adjacent the reduced diameter 87 of sleeve 64 until sufficient lengths of mandrel 14 have been added to position the cage and dogs adjacent the controlled gap 71 of the expansion joint of the tubular patch, at which time the enlarged diameter 73 of the sleeve 64 will move adjacent the cage 68 and dogs 74, thereby locking the dogs into the controlled gap 71.

After adding a sufficient length of mandrel 14 to the lower half of the running tool to correspond to the central patch body 60, a seat collar 63 (see Figure 3A) is

connected to the top of the mandrel 14, and supports a sleeve 64 that has a seat thereon and is connected to the seat collar 62 by pins 66. During expansion of the patch, a ball 68 or other type of plug lands on the sleeve seat 64 to close and seal the throughbore permitting increase in pressure within the running tool and develop the required forces to expand the tubular patch. Alternatively, the ball could land on a permanent seat, or the seat collar 62 could be furnished with a solid plug to use in place of a ball and seat.

A final length of mandrel 14 is added to the lower half of the running tool above the seat collar 62. An upper collet ring 50 is positioned in sliding engagement about the mandrel 14. A plurality of collet fingers 46 extend upward from the upper collet ring 50 and terminate in expander members 47 with curved surfaces 48 at their upper ends, as shown in Figure 1D. The upper collet ring, collet fingers and expander members are lowered to engage the tapered surface 53 at the top of the upper expander body 52. An upper shear collar 42 is threadedly engaged with adjusting mandrel 40 and is placed about the mandrel 14 and lowered into engagement with the top 49 of expander members 47 of the expander collet 46. A connector 34 is attached to the top of the mandrel 14. The collet support hub 44 of the upper shear collar 42 supports the top expander members 47, thus preventing inward radial movement of the top expander members during setting of the tubular patch. Referring to Figure 2E, the lower threads of sleeve 27 are threaded over the upper thread of adjusting collar 39 until the sleeve 27 and adjusting collar 39 are

completely telescoped within one another. Similarly, the lower threads of adjusting collar 39 are threaded over the upper threads of the adjusting mandrel 40 until the bottom end 41 of adjusting collar 39 abuts the top of the shear collar 42.

After checking to ensure that the lower half of the running tool has been lowered sufficiently within the surface suspended tubular patch to position the lower ends 120 of the lower expanders below the bottom of lower expander body 98, the lower half of the running tool is raised, moving the inner surface 110 and the bottom surface 111 of the shear collar into engagement with the lower expanders 120. The expanders 120 are thereafter raised until the outer curved surface 121 of the expanders 120 engage the tapered bottom 123 at the bottom of the lower expander body 98, as shown in Figure 1H.

With sufficient tensile strain maintained on the lower half of the running tool, the upper half of the running tool may now be attached to the lower half of the running tool and adjustments made for running the tubular patch to the desired setting depth within the well. The upper half of the running tool may be assembled as a unit from the top, as shown in Figures 1A - 1C and Figure 2A.

The upper end of the upper half of the running tool includes a conventional top connector 12 that is structurally connected by thread 16 to the running tool inner mandrel 14. A throughport 18 in the mandrel 14 and below the top connector 12 allows fluid pressure within the interior of the running tool to act on the outer connector 20, which as shown includes conventional seals for sealing between the

mandrel 14 and the outer sleeve 28. A shear sleeve 22 may interconnect the outer connector 20 to the connector 12, so that downward forces in the work string WS may be transmitted to the outer sleeve 28 by shoulder 26 acting through the shear sleeve 22. A predetermined amount of fluid pressure within the running tool acting on the outer connector 20 will thus shear the pin 24 and allow for downward movement of the outer sleeve 28 relative to the connector body 12.

Figure 1B shows another outer connector 20A and an inner connector 30. Fluid pressure to the inner connector 30 passes through the throughport 18A, and connector 30 is axially secured to the inner mandrel 14. Fluid pressure thus exerts an upward force on the inner connector 30 and thus the mandrel 14, and also exerts a further downward force on the outer sleeve 28A due to the outer connector 20A. Those skilled in the art will appreciate that a series of outer connectors, inner connectors, sleeves and mandrels may be provided, so that forces effectively "stack" to create the desired expansion forces, as explained subsequently. It is a particular feature of the present invention that a series of inner and outer connectors, outer sleeves and mandrels exert a force on each the upper expander body and lower expander body in excess of 100,000 pounds of axial force, and preferably in excess of about 150,000 pounds of axial force, to expand the expander bodies and effect release of the running tool from the tubular patch.

Figure 1B shows a conventional connector 20A for structurally interconnecting lengths of outer sleeve 28, while connector 30 similarly connects

lengths of mandrel. The lower end of sleeve 28A is connected to connector 32 to complete the upper half of the running tool 10, as shown in Figure 2A.

The upper half of the running tool 10 as above described may be connected to the lower half of the running tool (including the suspended tubular patch) by engagement of threads shown at the bottom of mandrel 14, as shown in Figure 2A, with threads in the top of connector 34, as shown in Figure 2B. With the running tool in tension while supporting the tubular patch on the expanders 120, the telescoped sleeve 27 and adjusting collar 39 are positioned to engage the thread 38 on the bottom of the adjusting collar 39 with the thread on the top of adjusting mandrel 40. The adjusting collar 39 and sleeve 27 are un-telescoped and the thread 36 on the bottom of the sleeve 27 is engaged with the external thread at the top of the adjusting collar 39, and the thread on the top of the sleeve 27 is engaged with the thread at the bottom of the connector 32, as shown in Figure 1C. The upper shear collar 42 is adjusted downward on the lower threaded end 44 of the adjusting mandrel 40 until the expander members 47 with curved surfaces 48 abut the top internal tapered surface 53 of the upper expander body 52. With the tubular patch now properly supported on the running tool, a work string WS is connected to the top connector 12 and the tubular patch and running tool are conveyed to the setting depth within the well.

The tubular patch is set by seating a ball 68 or other plug on the sleeve seat 63 of the seat collar 62 and increasing fluid pressure to activate the plurality of

pistons 20, 30 of the running tool to develop the required tensile and compressive forces to expand the tubular patch. Compressive forces are delivered to the upper expander members 47 to expand the upper expander body 52 of the tubular patch by shear sleeve 22, outer connectors 20 and 20A, sleeves 28, connector 32, sleeve 27, adjusting collar 39, adjusting mandrel 40 and upper shear collar 42 to axially move expander members 47 downward into the enlarged bore 59 of the upper expander body 52, thus expanding the exterior surface of the upper expander body 52 and bringing packing 54, 56 and slips 58 into respective sealing and gripping engagement with the casing C.

Simultaneously, tensile forces are delivered to the lower expander members 120 to expand the lower expander body 98 of the tubular patch by top connection 12, mandrels 14, inner connectors 30, connector 34, seat collar 62, connector 65, lower body 108 and lower shear collar 124 to axially move expander members 120 into the enlarged bore 117 of the lower expander body 98, thus expanding the exterior surface of the lower expander body 98, and bringing packing 102, 104 and slips 106 into respective sealing and gripping engagement with the casing C. Tensile and compressive forces developed by the running tool in expanding the tubular patch are prevented from closing the axial controlled gap 71 of the expansion joint by locking the dogs 74 within the controlled gap 71 as previously discussed.

As the running tool continues to "stroke" under fluid pressure and the upper expander body 52 and lower expander body 98 are expanded against the casing, sufficient forces are developed by the running tool to effect shearing of the lower shear collar 124, and optionally also the upper shear collar 42, to release the running tool 10 from the expanded tubular patch. The upper expander members 47, collet fingers 46 and collet ring 50 are forced downward inside the upper expander body until shoulder 51 of collet ring 50 abuts internal shoulder 55 of upper expander body 52, stopping further downward axial movement of the expander members 47. Increased fluid pressure continues to move compressive members of the running tool downward, shearing the controlled thin walled section of the upper shear collar 42, allowing the threaded hub of the shear collar to move toward the collet ring 50, thereby permitting the expander members 47 and the upper collet fingers 46 to flex inward, as permitted by the axial gaps between the collet fingers 46. As the work string WS is raised to pull the running tool from engagement with the tubular patch, the upper shoulder of seat collar 62 abuts the collet ring 50, as shown in Figure 3A, lifting the upper collet and expander from engagement with the upper expander body 52.

Simultaneously, the lower expander members 120, outer collet fingers 118, inner collet fingers 116, inner collet ring 112 and outer collet ring 114 and its upper extension 100 are forced upward inside the lower expander body 98 until the top shoulder 101 of upper extension 100 abuts the bottom shoulder 82 (Figure 1F) of

the cage 68 that is retained in its locked position by virtue of the dogs 74 positioned in the axial controlled gap 71 of the expansion joint 70. Increased pressure continues to move tensile members of the running tool upward, shearing the controlled thin walled section of the lower shear collar 124, allowing the threaded hub of the shear collar to move into abutment with the inner collet ring 112, thereby shifting upward the inner collet ring 112, the inner collet fingers 116 and the attached expander members 120A, until limit pin 115 abuts the upper end of slot 113 in the outer collet ring 114. This upward shifting of the inner expander members 120A and the inner collet figures 116 move the inner expander members 120A axially from outer expander members 120 on the outer collet fingers 118. Both expander members 120 and 120A can now flex inwardly toward the reduced diameter 119 of lower body 108, as shown in Figure 4A. The lower sheared portion of shear collar 124 is caught by lower retainer 126, as shown in Figure 4A. As the running tool 10 is raised upward by the workstring WS relative to the tubular patch, the top shoulder 107 of lower body 108 engages the bottom of collar 90 attached to sleeve 64. Continued raising of the workstring moves the enlarged diameter 73 of sleeve 64 from locking engagement with the dogs 74 and positions the reduced diameter portion 87 of sleeve 64 adjacent the dogs 74. The cage 68 and dogs 74 are thus released from the controlled gap 71 within the tubular patch as the running tool is released from the tubular patch and pulled from the well.

Those skilled in the art will appreciate that the patch of the present invention provides a highly reliable system for sealing within a casing, and is particularly designed for a system that minimizes the annular gap between the sealing element and the casing under elevated temperature and pressure conditions that are frequently encountered in downhole thermal hydrocarbon recovery applications. In some applications, an expansion joint along the length of the patch body may not be required, and thus the dog and cage assembly discussed above used to limit or prevent axial movement of the upper and lower expander bodies may be eliminated. While two upper seals and two lower seals are shown, at least one upper seal on the upper expander body and at least one lower seal on the lower expander body will be desired for most applications.

Those skilled in the art will appreciate that the running tool of the present invention may also be used in various applications for expanding the diameter of a downhole tubular. In one application, only a mid-portion of a downhole tubular may be expanded, e.g., to assist in closing off a water zone from hydrocarbon zones above and below the water zone. In that case, the downhole tubular may be expanded with a tool similar to that disclosed above. An expanded recess may be provided in which the expanded members 120 may be positioned, and the downhole tubular expanded with hydraulic forces to pull the inner tool mandrel upward, as disclosed herein. For this application, the outer housing of the tool may be secured by slips to a top portion of the outer tubular which will not be expanded.

In other applications, substantially the entire length of the outer tubular may be expanded by performing a series of expansion operations, each initiated by grippingly engaging the body of the tool with an upper portion of the outer tubular, using hydraulic forces as disclosed herein to pull an inner mandrel of the tool upward and expand the outer tubular to a position below the engaging slips, and then raising the engaging slips to a higher level in the well while leaving the lower expanders below the upper end of the expanded tubular. Those skilled in the art will appreciate the significant advantages of the tubular expander and method of the present invention in that, if for some reason the tool is not able to expand the outer tubular during the expansion operation, fluid pressure may be increased to allow the expansion members 120 and 120A to axially separate, thereby allowing the tool to be easily retrieved to the surface through the unexpanded portion of the outer tubular.

As disclosed herein, a preferred embodiment of the invention for forming a tubular patch includes a first plurality of pistons for raising the lower expander members 120, and another plurality of pistons for lowering the upper expander members 47. This configuration significantly improves the reliability of the tool, and allows the operator to effectively select the desired axial force for the expansion operation by stacking pistons, as discussed above. In a less preferred embodiment, one or more hydraulic pistons may be provided, and either hydraulic flow channels or mechanical linkage mechanisms used to convert the force from the

one or more pistons to opposing upward and downward forces which will raise the lower expanders and lower the upper expanders, respectively.

It will be understood by those skilled in the art that the embodiments shown and described are exemplary and various other modifications may be made in the practice of the invention. Accordingly, the scope of the invention should be understood to include such modifications, which are within the spirit of the invention.